

## **SPECIFICATION**

Please replace the paragraph on lines 31-33 of page 4 with the following paragraph: --

Fig.\_1 depicts a schematic outline of an assembly for carrying out the automated forge welding method according to the invention.--

Please replace the consecutive paragraphs starting on line 18 and ending on line 29 of page 5 with the following paragraphs: --

Fig.\_8 shows a longitudinal section view of a spear which is inserted into a pair of forge welded tubulars and which carries ring shaped assemblies of EMAT transmitters and receivers at each side of the weld.

Fig.\_9 shows a longitudinal sectional view of a weld between tubulars through which an ultrasonic signal is transmitted.

Fig.\_10a-e show a three-dimensional view of an EMAT transmitter and receiver assembly and how the acoustic signal is transmitted into the tubular wall.

Fig.\_11 shows various suitable configurations of the EMAT transmitter and receiver assemblies.--

Please replace the paragraph on lines 23-26 of page 6 with the following paragraph: --

Fig.\_20 is a schematic cross-sectional view of an external shield gas chamber in which a cold fluid is injected during the cool down phase after a forge welding operation.-

Please replace the paragraph on lines 23-24 of page 7 with the following paragraph: --

Fig. 28 is an enlarged longitudinal section view of the prepared and mated ends and marker shown in Fig.\_27.--

Please replace the paragraph starting on line 30 of page 7 with the following paragraph: --

As shown in Fig.\_1 the positions of the tubular ends 3 and 4 that are to be forge welded together are monitored by cameras 1 and 2 which are coupled to a camera signal processor 5 which automatically controls a gripping assembly 6, such that the spacing S between the heated tubular ends 3A and 4A is well defined during the heat up phase and

the tubular ends are moved towards each other when a pyrometric control unit indicates that the tubular ends have reached a predetermined minimum and/or maximum temperature along at least a substantial part of the circumference thereof[[ ]], whereupon the gripping assembly is activated to move the tubular ends 3A and 4A towards each other over a predetermined distance (S+D) which exceeds said spacing (S) with an additional distance (D) of less than a few millimeters, such that a forge weld is obtained of a substantially equal and high quality over the entire circumference of the forge welded ends and only minimal external and/or internal upsets of the forge welded ends 3A, 4A is created[[ ]], which upsets do not have to be removed afterwards by grinding, milling or machining.--

Please replace the paragraph starting on page 33 line 20 with the following paragraph: --

In its simplest variant, in-situ quenching of welds can take place externally using a portable collar 407A, 407B as indicated in Fig.\_20 using quench media, such as liquid nitrogen, argon, carbon dioxide or an aqueous liquid. The collar 407A, 407B shown in Fig.\_20 is manufactured with a hinged fastening 403 and an inside diameter to match a particular pipe outer diameter (OD). The collar 407A, 407B thus forms a split ring which, when closed, will fully encircle the welded area of the pipe and fasten around it using the fastener 401. In operation the welded area is fully encircled with the split ring that is fastened with 401, a supply of quench media is available through the supply hose 404 and is released into the interior of the split ring collar 407A, 407B by opening the valve 402. Quench media circulates through the split ring collar 407A, 407B until it reaches the baffle 405 whereupon it exits via a drain hole 406.--

Please replace the paragraphs starting on page 34 line 16 and ending on line 33 with the following paragraph: --

For thicker wall tubes, where the cooling rate may vary significantly through the wall, external quenching may need to be used in conjunction with internal quenching using an internal spear 430 as illustrated in Fig.\_21. This is principally dependant on the metallurgy of the steel in question, particularly carbon content, and the quench media employed. For standard OCTG materials through-wall cooling to approximately 300° C is preferably be done in approximately 1 minute.

For certain applications, such as thin wall tube and low carbon steel it is possible to quench the steel from a fully austenitic structure to fully martensitic using an internal

spear 30 as shown in Fig.\_21 as an alternative to external quenching as shown in Fig.\_20. Further, for thicker steel sections and higher carbons steels it is necessary to use a combination of internal and external quenching to ensure even and rapid cooling across the pipe wall.--

Please replace the paragraph starting on page 35 line 24 with the following paragraph: --

It should be noted that not all of these elements may need to appear in every spear 430 but that any combination of the elements described above is possible. In addition, alternative-heating elements incorporating pairs of contacts positioned above and below the weld area 419 for heating using e.g. resistance are also options.--

Please replace the paragraph starting on page 36 line 32 with the following paragraph: --

Immediately after the forge weld has been made, quench media is pumped through the supply hose 408 and out through the nozzles 418 to cool the welding zone 419 rapidly. If necessary this is done simultaneously with external quenching by means of the split collar 407A, 407B shown in Fig.\_20.--

Please replace the paragraph starting on page 37 line 22 with the following paragraph: --

The split external cooling collar 407A, 407B shown in Fig.\_20 and the internal spear 430 shown in Fig.\_21 are appropriate to a range of welding processes such as friction welding, flash butt welding, shielded active gas welding etc. whenever post weld heat treatment is required. Heating for tempering purposes may be carried out from inside the pipe, from outside the pipe or in combination. Combined heating may be particularly effective in the case of thick wall pipe (pipe wall thickness approximately >5 mm).--

Please replace the paragraphs starting on page 38 line 5 and ending on line 30 with the following paragraphs: --

The internal spear 430 shown in Fig.\_21 may have an integral induction-heating coil 423 that is centered over the weld area and powered through an umbilical cable. Where the spear 430 includes components such as injection nozzles 418 and/or ferrite bars 420 then the induction coil 423 may be installed in a secondary housing and moved into position over the weld area immediately prior to use. The relatively through-wall

nature of induction heating allows tempering of a fully martensitic structure in a comparably short time, usually no longer than 4 minutes depending on the precise metallurgy of the welded area.

An additional external heating coil (not shown), which is well documented technology, may be centered over the weld area 419 using spacers as indicated, and powered to allow tempering. The external heating coil may consist of a split ring embedded in the split collar 407A, 407B shown in Fig.\_20 or may consist of a fully encircling coil. Where the proximity of the coil to metallic fixtures around the weld station are likely to cause extraneous heating then the coil is positioned some short distance from the weld station. When welding is done in a sealed chamber formed by the collar 407A, 407B containing shield gases, whether they are non-oxidizing or reducing, then it is preferred to position the coil inside this chamber.--

Please replace the paragraph starting on page 39 line 9 with the following paragraph: --

The internal spear 430 shown in Fig.\_21 may have resistance heating contacts (not shown) located circumferentially around its periphery equidistant above and below the welding zone 419. Current, typically 400 Amps, is passed between these contacts through an umbilical cable to heat through electrical resistance. Heating is controlled by an optical or contact pyrometer located inside or outside the pipe that is in a control loop which regulates the passage of current.--

Please replace the paragraph starting on page 39 line 28 with the following paragraph: --

Optionally, external electrical contacts may be positioned above and below the welding zone 419 in the configuration described in Fig.\_21. Where the proximity of the external contacts to metallic fixtures around the weld station are likely to cause extraneous heating then the contacts may be positioned some short distance from the weld station and moved into position as and when required. When welding is done in a sealed chamber containing shield gases, whether they are non-oxidising or reducing, then it is preferred to position the contacts inside this chamber.--

Please replace the paragraphs starting on page 40 line 21 and ending on page 41 line 4 with the following paragraphs: --

It may be beneficial for certain materials being welded using forge welding to be heat treated prior to use to improve their mechanical or corrosion properties. In these

instances a heating device such as the heating coil 423 shown in Fig.\_21 may be incorporated into the spear housing or added as an accessory in an additional housing. Particularly with smaller diameter pipes 415, 425 this heating device may be used as the primary heating device for forge welding.

In certain circumstances, especially with larger diameter tubulars, gripping and compression devices 412, 414, 422, 426 may also be incorporated into the internal spear 430. This has the advantage that an additional external device, such as the split collar 407A, 407B shown in Fig.\_20, is not required, so that the spear 430 can be employed to forge weld tubulars downhole in a well.--